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FINAL REPORT

W-98-R(SI), STUDY I

Comparative effects of exploitation on semi-isolated and contiguous bobwhite populations

Submitted by
Cooperative Wildlife Research Laboratory, SIUC

Presented to
Illinois Department of Conservation

March 1991

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FINAL REPORT

STATE OF ILLINOIS

W-98-R(SI),STUDY I

Project Period: July 1, 1987 through December 31, 1990

Study I: Comparative effects of exploitation on semi-isolated and contiguous bobwhite populations

Prepared by John L. Roseberry
Cooperative Wildlife Research Laboratory
Southern Illinois University-Carbondale

Need: Intensified land use has reduced and fragmented suitable habitat for the northern bobwhite over much of its midwestern range. The result has been a substantial decline in quail abundance as well as increased isolation of many remaining populations. Current harvest management assumes that the impact of hunting on semi-isolated or isolated populations is similar to that experienced by populations occupying contiguous habitat. This assumption may not be valid; populations with limited opportunity for ingress/egress may be less resilient to sustained harvest. Scientific information regarding this possibility and its implications is needed to ensure continued proper management of the bobwhite under conditions of intensive land use.

Objectives:

1. To investigate the effects of harvest on local bobwhite populations and identify the compensatory mechanisms involved.
2. To determine if these effects and mechanisms differ according to degree of isolation of the exploited populations.

ABSTRACT

Intensified land use has reduced and fragmented northern bobwhite habitat in the Midwest resulting in increased isolation of many local populations. This research was intended to determine if degree of isolation affected population response to exploitation. Two groups of bobwhites, differing in degree of isolation, were subjected to 3 years of experimental harvesting on Crab Orchard NWR in southern Illinois.

A total of 585 quail were removed from the 2 study areas representing an estimated average annual harvest rate of approximately 50%. Following 3 years of controlled exploitation, fall population level on the semi-isolated area was reduced to 27% of initial density compared to 40% on the non-isolated tract. Comparable spring densities were 36% and 49% of initial levels, respectively. The degree of additivity between fall-spring harvest and natural mortality on the semi-isolated area was similar to that expected for bobwhite populations in general. In contrast, there was almost total compensation on the non-isolated area due to ingress of birds from the surrounding protected area. Consequently, overall impact of harvest on standing densities was about 20-30% greater on the semi-isolated area than on the non-isolated site. Population declines on both areas were, however, much greater than expected given the estimated level of harvest. The primary reason was that neither population achieved any degree of compensatory reproduction and exhibited recruitment rates far below normal for exploited populations. Whether this poor reproductive performance reflected conditions unique to the study site or is indicative of a more general situation is unknown at present.

High annual turnover, susceptibility to periodic catastrophic weather, and the transitory nature of their habitat would appear to increase the vulnerability of small, isolated local bobwhite populations. In addition, the natural recolinization of depleted isolated patches of habitat is hindered by the species' inherently low mobility. Based on these considerations coupled with specific findings from this study, a series of recommendations for harvest and habitat management were made.

INTRODUCTION

Wildlife officials have become increasingly concerned about the widespread decline of northern bobwhite (Colinus virginianus). Over the past 2.5 decades, populations of this important gamebird have decreased significantly in at least 21 of the 30 states comprising its primary range (Droege and Sauer 1990). In Illinois, annual hunter harvests have gone from > 2.5 million in the late 1950's (Preno and Labisky 1971) to < 1 million in the 1980's (Anderson et al. 1990).

Short-term fluctuations in bobwhite abundance are commonly associated with weather perturbations whereas long-term trends are related primarily to habitat conditions (Roseberry and Klimstra 1984). Intensified land use, especially agricultural, has resulted in loss of suitable upland habitat and therefore a general decline in abundance of bobwhites and other upland wildlife throughout the Midwest (Burger 1978, Klimstra 1982, McCorkle and Halver 1982). Vance (1976) documented typical land use changes on a 1,117-ha area in southeastern Illinois from 1939 to 1974 that included a large increase

in rowcrops and field size, almost complete elimination of grasslands, and an 84% loss of brushy fencerows.

In addition to reducing overall habitat availability, present-day land use often results in remaining habitat being distributed in relatively isolated patches separated by tracts of inhospitable land or other barriers, a phenomenon known as habitat fragmentation. Organisms occupying these patches are thought to be at greater risk than those in larger tracts or connected smaller tracts of habitat (Gilpen 1987). Roseberry and Klimstra (1984) warned that bobwhites in marginal and/or isolated habitat may be more susceptible to weather, predation, and hunting. In particular, bobwhites in island-type settings may be more vulnerable to overshooting because a) hunting effort can be concentrated and thus more effective, and b) opportunity for population recovery from ingress is limited (Roseberry 1987). Edwards et al. (1981) expressed a similar concern for isolated cottontail (*Sylvilagus floridanus*) populations.

The present study was designed to test the hypothesis that bobwhite population responses to exploitation are influenced by degree of population isolation. Two areas in southern Illinois were selected for study. The resident bobwhite population on one area was relatively isolated from surrounding habitat and populations by physical features of the landscape. The other area was situated in relatively contiguous habitat. Both populations were subjected to similar levels of controlled exploitation over a 3-year period and key parameters such as density, recruitment, and over-winter survival were monitored.

STUDY AREAS

Research was conducted on the closed portion of Crab Orchard National Wildlife Refuge (NWR) in Williamson County, southern Illinois. Two areas, similar in size and vegetative cover but differing in degree of isolation, were selected as study sites. The 2 areas, located 4.8 km apart and separated by Crab Orchard Lake, featured generally flat terrain and a uniform grid system of all-weather roads that facilitated trapping and census activities. Vegetative cover was a mix of upland hardwoods, brush, early successional old fields, grassland, and corn fields. The 177-ha non-isolated area (A13) was surrounded by other suitable bobwhite habitat whereas the 185-ha semi-isolated area (A3) was essentially a large peninsula with 76% of its perimeter adjacent to Crab Orchard Lake. An additional 7% of A3 bordered nonhabitat (a large fescue [*Festuca arindinacea*] pasture and permanently wet bottomland hardwoods); only 17% of the perimeter was accessible to ingress from adjacent populations. To reduce this possibility, I attempted to livetrap and remove all resident coveys within 0.5 km of this border during each year of study. The bobwhite population on A3 was further isolated by the distribution of habitat on the area. Over 91% of all coveys encountered during the study (74 of 81) occupied a rectangular central core area of 76.5 ha that was surrounded by inferior habitat. Preharvest densities in this core were estimated at 267 birds/100 ha in autumn 1987 compared to 20/100 ha in the perimeter area (122 birds/100 ha total). Comparable population density on A13 was 150 birds/100 ha. Both study populations had been subjected to live trapping during 1983-1985 (Roseberry et al. 1987) but were undisturbed in 1986 and considered at or near carrying capacity.

Winter weather during the study years was unremarkable. Minimum daily temperatures during December-February 1987-88, 1988-89, and 1989-90 averaged 0.5 to 1.6°C below the previous 40-year mean, but duration and depth of snowcover was normal to below-normal. A severe drought of historic proportions occurred during the 2nd summer of study (1988) and apparently impacted bobwhite reproduction and abundance in southern Illinois (Roseberry 1989).

METHODS

Population Estimates

Seasonal population estimates on the 2 areas were obtained in early November (pre-harvest), early January (post-harvest), and mid-March (pre-breeding) using the walk-census approach (Roseberry and Klimstra 1984). Crews of 8-12 workers, spaced at intervals of approximately 9-10 meters, systematically traversed each area and counted all bobwhites flushed. When singles or small groups were encountered, the immediate area was thoroughly searched to locate the entire covey. Censuses required approximately 50-55 man-hours per 100 hectares to complete. Dimmick et al (1982) reported only 50% census accuracy when researchers were spaced at 20-m intervals. Janvrin et al (1989) achieved approximately 60% accuracy with a census effort of 39-44 man hours per 100 ha with crews of 13-26 inexperienced counters spaced at 10-m intervals. Personal experience has shown that maximum census accuracy and efficiency can be achieved with closely-supervised, slowly moving crews of 10-12 persons. Daily trapping and research activities suggest that census accuracy was at least 85-90% during the current study.

A 3.4-km, 8-stop route was established on A3 and a 5.2-km, 9-stop route on A13 for the purpose of monitoring summer male whistling. All calls were

recorded during 3-minute periods at each stop. Routes were run 5 times each in 1987 and 10 times each in 1988, 1989, and 1990 beginning at sunrise from mid-June through mid-July. Routes were run on separate days in 1987 and on the same day (alternate order) during the following 3 years.

Regional Population Trends

For use as a control, regional population trends were determined from annual hunter questionnaire data collected separately by the Illinois Department of Conservation (Anderson et al. 1990) and the Cooperative Wildlife Research Laboratory, Southern Illinois University Carbondale (Roseberry 1990a).

Experimental harvesting

Controlled exploitation was accomplished by live-trapping and removing a pre-determined number of bobwhites from each study area during autumn 1987, 1988, and 1989. Fifteen to 20 wire "walk-in" traps baited with cracked corn/milo were set on each area from approximately 7 November through December to simulate the normal Illinois upland game season. Birds predated at trap sites were considered "harvested." Captured birds were transported to central Illinois and released under the direction of Illinois Department of Conservation Division of Wildlife Resources biologists.

RESULTS

Experimental harvests

A total of 585 bobwhites (541 trapped, 44 predated) were removed from the 2 study areas during the 3 years of controlled exploitation (Table 1). Computed annual harvest rates averaged 53% on A3 (range 47-60%) and 54% on A13 (range 51-60%). Actual harvest rates were estimated at 48 and 49%,

respectively, assuming a 10% negative census bias. Approximately 100 quail were also removed from land adjacent to that portion of A3 subject to ingress.

Seasonal Population Changes

Although annual harvests were similar on the 2 study areas (Table 1), average total fall-spring losses were higher on A3 than on A13 (65 vs. 56%), but the small sample size (n = 3) precluded statistical significance ($\underline{P} >$ 0.20). Because of the method of data acquisition (seasonal counts), effects of ingress/egress could not be separated from mortality except for known harvest. There was, however, evidence of ingress onto A13 during each year of study. Net population gains were recorded on A13 from January through mid-March during 2 years of study while the other year showed a net gain during November-December after the known harvest was accounted for (Table 2). There was no evidence of ingress onto the semi-isolated A3 during the study.

Relative population gains from spring to fall (recruitment) were measured directly by seasonal censuses (Table 3) and indirectly by autumn juvenile:adult ratios (Table 4). Net summer gains for all years averaged higher on A3 than on A13 (105 vs. 78%; $\underline{P} = 0.087$). During the years of exploitation, summer gains averaged 90% on A3 and 71% on A13 ($\underline{P} = 0.20$). In contrast, fall juvenile:adult ratios were significantly higher ($\underline{P} < 0.01$) on A13 than on A3 (3.17:1 vs 1.82:1).

Annual Population Trends

Bobwhite abundance declined on both areas throughout the study (Table 5). Following 3 years of controlled exploitation, March populations were reduced to 36% of pre-study levels on A3 and 49% of pre-study levels on A13 (Fig. 1). Final November densities were 27% and 40% of pre-study levels, respectively

respectively (Fig. 2). Indices of regional bobwhite abundance fluctuated between 86 and 92% of pre-study levels.

Male bobwhite call count indices were similar on the 2 study areas prior to the initiation of harvesting (1987) but were significantly higher ($\underline{P} <$ 0.10) on A13 than on A3 during the following 3 years (1988-1990) (Table 5). Indices could not be compared among years because different researchers recorded calls.

DISCUSSION

Population Responses to Exploitation

The degree to which hunting and nonhunting losses of bobwhite are additive, and the short- and long-term impact of various harvest regimes on standing densities are critical management issues that lack definitive answers. Based on a long-term, observational study of a hunted population in southern Illinois, Roseberry and Klimstra (1984) concluded that the fall-spring hunting-nonhunting mortality relationship was intermediate between fully additive and fully compensatory, but closer to the additive end of the spectrum. Using a population model, Roseberry (1979) predicted the impact of various harvest rates and strategies on standing densities. A need remains, however, for experimental studies designed to test alternative hypotheses regarding the impact of exploitation on native bobwhite population levels and dynamics (Pollock et al. 1989). The present experimental study, while addressing a more limited question, nevertheless provided certain data relevant to the broader objective.

Assuming 50 percent fall-spring mortality in the absence of hunting (Mosby and Overton 1950, Kozicky and Hendrickson 1952, Kabat and Thompson 1963, Roseberry et al. 1979), a fully additive situation on the study areas

would have resulted in fall-spring losses of approximately 74% given a mean harvest rate of about 48% [((0.50 + 0.48) - (0.50 x 0.48)) = 0.74]. Under a fully compensatory situation, losses would have been about 50%. Observed mean fall-spring mortality of 65.2% on A3 and 56.4% on A13 suggests that "hunting" losses were more additive on the semi-isolated than on the non-isolated area. Other factors, however, such as relative population density and winter weather also influence over-winter survival of bobwhites (Roseberry and Klimstra 1984). Given these factors and prevailing harvest rates for each study year, the above-mentioned model predicted mean fall-spring losses of 67.5% on A3 and 71.3% on A13. Observed losses on the semi-isolated A3 ($\bar{X}$ = 65.2) were only slightly lower than expected whereas losses on the non-isolated A13 ($\bar{X}$ = 56.4%) were well below predicted. Over-winter population declines on the non-isolated A13 were mitigated by ingress of quail from surrounding areas as evidenced by the census data.

The impact of harvest on standing densities was 20-30% greater on the semi-isolated A3 than on the non-isolated A13 (Figs. 1 and 2). This finding was consistent with the original research hypothesis although the underlying reasons for the differential were not entirely expected. The degree of additivity between "hunting" and natural mortality during fall to spring on the semi-isolated A3 was, in fact, similar to that predicted by Roseberry (1979) for bobwhite populations in general. In contrast, A13 experienced almost total compensation due to ingress of birds from surrounding areas. It must be emphasized that the area surrounding A13 was not hunted; therefore, A13 did not represent a typical population in contiguous hunted habitat.

Although relatively more severe on the semi-isolated than non-isolated population, harvesting had a greater-than-expected impact on standing

densities of both areas. According to Roseberry's (1979) model, the intensity of harvest imposed on the study populations would be expected to ultimately depress standing fall densities to about 75-80% of pristine levels. Following 3 years of exploitation, fall densities on A3 and A13 were 27.4% and 40.4% of pre-harvest levels, respectively, and apparently still declining (Fig. 2). This represents population reductions of 72.6 and 59.6%, respectively. Regional populations declined <10% over the same period, suggesting that study area declines were attributable mainly to trapping and removal. The primary reason for the greater-than-expected impact of exploitation was the failure of either population to exhibit any degree of compensatory reproduction.

Wild bobwhite populations normally demonstrate considerable resilience to exploitation through the partially compensatory nature of hunting and nonhunting mortality as well as density-dependent adjustments in reproduction (Roseberry 1979, 1982, Roseberry and Klimstra 1984). The 2 study populations exhibited the 1st mechanism but not the 2nd. Bobwhite recruitment rates have been reported for at least 9 locations in the United States over periods ≥ 5 years (Mosby and Overton 1950, Kozicky and Hendrickson 1952, Kabat and Thompson 1963, Ellis et al. 1972, Klimstra 1972, Dimmick 1974, Roseberry et al. 1979, Roseberry and Klimstra 1984). When ranked from highest to lowest, the 3 highest and 4 of the top 5 reproducing populations were hunted, whereas the 4 lowest were unhunted. The weighted average summer gain for the hunted populations was 275% compared to 142% for nonhunted populations. The most plausible explanation why exploited populations tend to exhibit higher recruitment rates is that hunting does indeed have an additive component that acts to depress breeding densities below carrying capacity.

Mean summer gains recorded during the period of exploitation (90.2% on A3 and 71.1% on A13) were far below normal for exploited populations and even below those characteristic of unhunted bobwhites. Autumn juvenile/adult ratios on A3 (1.82:1) were consistent with estimated recruitment rates assuming adult summer mortality did not greatly exceed 20% (Roseberry 1974). In contrast, juvenile/adult ratios on A13 (3.17:1) were higher than expected but still well below normal for hunted populations (Roseberry and Klimstra 1984).

Whether the poor reproductive performance of the study populations reflects conditions unique to Crab Orchard NWR, or is indicative of a more general situation is unclear. A severe drought adversely affected regional bobwhite productivity in 1988 (Roseberry 1989) and presumably the study areas as well. However, recruitment rates on A13 were even lower in 1987 and 1989 than during the drought year and only slightly higher on A3. Another possibility is that late-winter food supplies and resulting physical condition of breeders were not optimum. Physical condition of females entering the breeding season is believed to be an important determinant in subsequent reproductive performance of galliformes including ring-necked pheasants (Phasianus colchicus) (Edwards et al. 1964, Gates and Hale 1975), red grouse (Lagopus lagopus scoticus) (Jenkins et al. 1963), and northern bobwhite (Latham and Studholme 1952, Dimmick 1974, Roseberry and Klimstra 1984). On Crab Orchard NWR, large wintering concentrations of Canada geese (Branta canadensis) feed in the same cropfields utilized by bobwhites and typically deplete them of wastegrain by mid-winter. Following a 1974 study of bobwhites on Crab Orchard NWR, Fernald (1977:66) wrote: ". . . interspecific competition precipitates severe winter-food depletion . . . . [and] Canada

geese are primarily responsible for the shortage of cultivated grains, particularly corn." The number of goose-use days on the refuge during the current study (8-10 million) was as high or higher than during Fernald's study (CWRL, unpubl. data).

Potential Implications of Habitat Fragmentation and Population Isolation

Habitat fragmentation is a problem most commonly associated with forests and forest communities (Harris 1984). However, the increasingly patchy aspect of wildlife habitat in agricultural areas is a growing concern as well (Kenney 1985). According to Wilcove et al (1986:237):

> "Fragmentation occurs when a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original. When the landscape surrounding the fragments is inhospitable to species of the original habitat, and when dispersal is low, remnant patches can be considered true 'habitat islands,' and local communities will be 'isolates'."

The above aptly describes the situation being faced by an increasing proportion of bobwhites in the Midwest. Earlier less intensive agriculture, with its small fields, diverse cropping patterns, and network of hedgerows and brushy fencerows provided bobwhites with a fine-grained, heterogenous landscape characterized by a high degree of connectivity. Such landscapes facilitated exchange of individuals and genetic material between and among neighboring coveys and groups of coveys. In contrast, rural landscapes today are often homogeneous and course-grained where the land is flat and fertile and extensively invaded by exurban development where it is not (Foreman and Godron 1986). In many parts of the upper Midwest, bobwhites now commonly

exist in small, relatively isolated patches of habitat separated from similar areas by physical barriers or large expanses of bare ground.

Habitat fragmentation implies a reduction in gross amount of living area for bobwhites and thus a reduction in their total numbers. But what about individuals that occupy patches of remaining habitat -- is their viability affected by degree of isolation as suggested by Roseberry and Klimstra (1984)? Gilpen and Soulé (1986) introduced the concept of Population Vulnerability Analysis (PVA), also referred to as Population Viability Analysis (Murphy et al. 1990), as an approach to addressing this question. This approach identifies 4 primary categories of phenomena that affect vulnerability of local populations: (1) genetic, (2) demographic, (3) environmental, and (4) intra-population interactions (Murphy et al. 1990; Shaffer 1981, 1987; Gilpin 1987).

Genetic considerations would include such factors as inherent adaptability and rate of gene flow. Unfortunately, there has been scant research on the genetics of wild bobwhites (Gutiérrez et al. 1983, Ellsworth et al. 1988, 1989). In general, avian species tend to show less genetic diversity than other vertebrates (Corbin 1977, Barrowclough 1980); and, although bobwhites occupy a wide geographic and climatic range (Rosene 1969), the species does not appear to be particularly adaptable.

Demographic characteristics of bobwhites, especially their high annual population turnover, may increase the vulnerability of small, isolated populations. Peak autumn densities are routinely reduced 50-80% by late winter - a seemingly dangerous situation for such groups. On the plus side, bobwhites can achieve high reproductive output and rapid population growth

under favorable conditions. However, conditions are not always favorable due to stochastic events as well as human involvement (or lack of it).

Bobwhite population fluctuations are closely tied to weather, especially in the Northeast, Southwest, and Midwest (Latham and Studholme 1952, Lehmann 1984, Roseberry and Klimstra 1984). In the Midwest, severe winters periodically depress populations to very low levels (Kabat and Thompson 1963, Stanford 1972, Roseberry and Klimstra 1984). Such susceptibility to stochastic, catastrophic events increases the vulnerability of small, relatively isolated populations (Shaffer 1987).

In addition, bobwhites occupy habitat that is transitory by nature. They need a relatively small amount of dense vegetation for protective cover and a proportionately larger amount of early successional vegetation for roosting, feeding, nesting, and brood rearing. This combination creates an inherently unstable situation. Early successional vegetation requires a moderate amount of periodic disturbance for creation and maintenance, whereas the persistence of heavy cover requires that the disturbance not be too frequent or too extensive. Bobwhite habitat can thus be adversely affected by too much human disturbance, or not enough. Again, the negative implications of this are magnified for small, semi-isolated or isolated populations.

Another set of factors affecting the vulnerability of isolated populations is their interaction with similar neighboring groups, i.e., so called "metapopulation dynamics" (Gilpen and Soulé, 1986). This would include such things as gene flow among groups, turnover rates of patches (extinction and recolonization), and patterns of patch occupancy. Although bobwhites have been the subject of numerous studies (Scott 1985), and a good deal is known about their biology, life history, and habitat preferences

(Stoddard 1931, Rosene 1969), Klimstra (1982) noted that this knowledge may not always be sufficient for addressing present-day situations and problems. The paucity of research on bobwhite population genetics has already been mentioned. In addition, little is known about the potential for recolonization of suitable but empty habitats. Bobwhites are normally quite sedentary (Murphy and Baskett 1952, Lewis 1954, Agee 1957, Smith et al. 1982), although individuals are capable of relatively long movements (> 8km) (Duck 1943, Loveless 1958). The frequency of such movements, the ultimate reproductive effectiveness of the migrants, and the maximum distance that such movements could be expected over inhospitable area are unknown at present.

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Harvest Management

Recommendations for acceptable or "safe" harvest rates for bobwhites vary considerably. Early recommendations ranged from 30 to 55 percent of pre-harvest populations (Errington and Hamerstrom 1936, Baumgartner 1944, Hickey 1955). Vance and Ellis (1972) suggested that a 70 percent annual removal might not be excessive whereas Rosene (1969) felt that winter mortality from all sources should not exceed 45%. More recent workers have recommended harvest rates of 40-45% (Roseberry 1979, Guthery 1986), <40% (Shupe 1987), and 30% (Landers and Mueller 1986). Roseberry (1990b) noted that conservative harvest strategies are more characteristic of private or commercial areas where maintenance of high standing densities are consistent with the goal of providing quality hunting for relatively few individuals. In contrast, more liberal regimes are often employed on public shooting areas where lower standing densities must be tolerated in order to provide recreational opportunities for the maximum number of hunters.

It is difficult, if not impossible, to control harvest rates on a regional or statewide basis, therefore, agencies attempt to regulate harvest through length and timing of open seasons and bag limits. Many Illinois quail hunters, while not necessarily wanting a longer season, complain that the season opens and closes too early (CWRL, unpubl. data). Roseberry (1987), however, argued that late season hunting is not advisable because of increased prey vulnerability, increased additivity of hunting mortality, and potentially adverse bioenergetic consequences. Curtis and Doerr (1989), citing the potential of increased additivity, also recommended against late season hunting in North Carolina. Experimental field research in Florida confirmed that late-season (February) hunting is additive to natural mortality (Pollock et al. 1989). The adverse effect of increased additivity is magnified by the fact that as fall-to-spring mortality increases linearly, the recruitment rate necessary to recover increases exponentially (Roseberry 1979). Furthermore, it must be remembered that study area populations did relatively poorly in terms of reproductive output. The possibility that this reflects a general rather than a local problem warrants further investigation. In view of the above, I recommend that:

1. Where it is possible to estimate and control the proportion of the population removed by hunting (including crippling), that proportion should not exceed 40-45% annually.
2. Hunting seasons should be structured so that the bulk of the harvest is taken in November and early December.
3. Late-season (>1 January) hunting or other recreational disturbances should be minimized during normal years and eliminated during harsh winters.

4. When possible, small isolated populations distanced from reservoir populations, should be given added, if not complete, protection.
5. Heavily hunted sites such as public shooting areas should be surrounded by a 0.5 km-mile wide protected buffer zone of good habitat.

Habitat Management

Traditional approaches to bobwhite habitat management (Ellis et al. 1969, Rosene 1969) and evaluation (Baskett et al. 1980, Schroeder 1985) generally focus on discrete areas without regard to their orientation in physical space. The spatial distribution of distinct habitat patches, their degree of connectivity, and distance to nearest reservoir populations are aspects of habitat evaluation that are relatively new to upland game managers. Clearly, however, these are no longer simply theoretical considerations. Extinction of local bobwhite populations and subsequent problems of natural recolonization occurred in the upper Midwest following a series of severe winters in the late 1970's (Urban 1978, Backs 1982, Henry and Shipley 1989). Therefore, I recommend that habitat be evaluated on a regional as well as a local basis to:

1. Identify relatively isolated patches or populations that might be vulnerable to local extinction and manage these areas accordingly.
2. Identify and protect critical corridors between habitat patches or reestablish such corridors where possible.

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Table 1. Simulated harvest of bobwhites on study areas, Crab Orchard NWR, Illinois, 1987-1989.

	Area			
	A3		A13	
Year	N[a]	% [b]	N	%
1987	118	52.2	134	51.5
1988	58	47.2	114	51.1
1989	59	60.2	102	60.0
Total	235[c]	53.2	350[d]	54.2

[a] Number of birds removed.

[b] Percentage of total November 1 population.

[c] 203 live captures, 32 predated.

[d] 338 live captures, 12 predated.

Table 2. Fall-spring population changes of bobwhites on study areas, Crab Orchard NWR, Illinois, 1987-1990.

	Area							
	A3				A13			
Period	1987-1988	1988-1989	1989-1990	$\bar{x}$	1987-1988	1988-1989	1989-1990	$\bar{x}$
Harvest [a]								
Trapping	-52.2	-47.2	-60.2	-53.2	-51.5	-51.1	-60.0	-54.2
Natural	-11.1	-4.1	-5.1	-6.7	19.6	-13.5	-5.9	0.1
Total	-63.3	-51.2	-65.3	-59.9	-31.9	-64.6	-65.9	-54.1
Post-harvest [b]	-24.1	-10.0	-5.9	-13.3	-24.3	17.7	10.3	1.9
Total fall-spring [c]	-72.1	-56.1	-67.3	-65.2	-48.5	-58.3	-62.4	-56.4

[a] November-December.

[b] January-March.

[c] November-March.

Table 3. Recruitment rates (percent summer gain) on study areas, Crab Orchard NWR, Illinois, 1987-1990.

Year	Area A3	Area A13
1987	151.1	100.0
1988	95.2	66.4
1989	81.5	82.8
1990	93.8	64.1
Mean[a]	105.4	78.3

[a] $\underline{P} = 0.087$.

Table 4. Sex-age composition of bobwhites removed from study areas, Crab Orchard NWR, Illinois, 1987-1989.

	Area					
	A3			A13		
Year	Juv	Ad	Juv/Ad	Juv	Ad	Juv/Ad
1987	70	30	2.33	96	31	3.10
1988	31	19	1.63	83	29	2.86
1989	30	23	1.30	78	21	3.71
Total	131	72	1.82[a]	257	81	3.17[a]

[a] $\chi^2 = 7.72$ $\underline{P} < 0.01$

Table 5. Bobwhite population counts on study areas, Crab Orchard NWR, Illinois, 1987-1990.

	Area	
Census	A3	A13
March, 1987	90	130
November, 1987	226	260
January, 1988	83	177
March, 1988	63	134
November, 1988	123	223
January, 1989	60	79
March, 1989	54	93
November, 1989	98	170
January, 1990	34	58
March, 1990	32	64
November, 1990	62	105

Table 6. Male whistling call counts on study areas, Crab Orchard NWR, Illinois, 1987-1990.

	Area				
	A3		A13		
Year[a]	N[b]	$\bar{X}$[c]	N	$\bar{X}$	*P*[d]
1987e	5	33.55	5	32.89	>0.50
1988f	10	17.68	10	22.48	=0.07
1989g	10	25.19	10	42.69	<0.001
1990g	10	10.95	10	20.38	<0.01

[a] Years with different letters had different recorders.

[b] Number of times route driven.

[c] Mean calls/stop

[d] 1987 comparisons unpaired; all others paired.

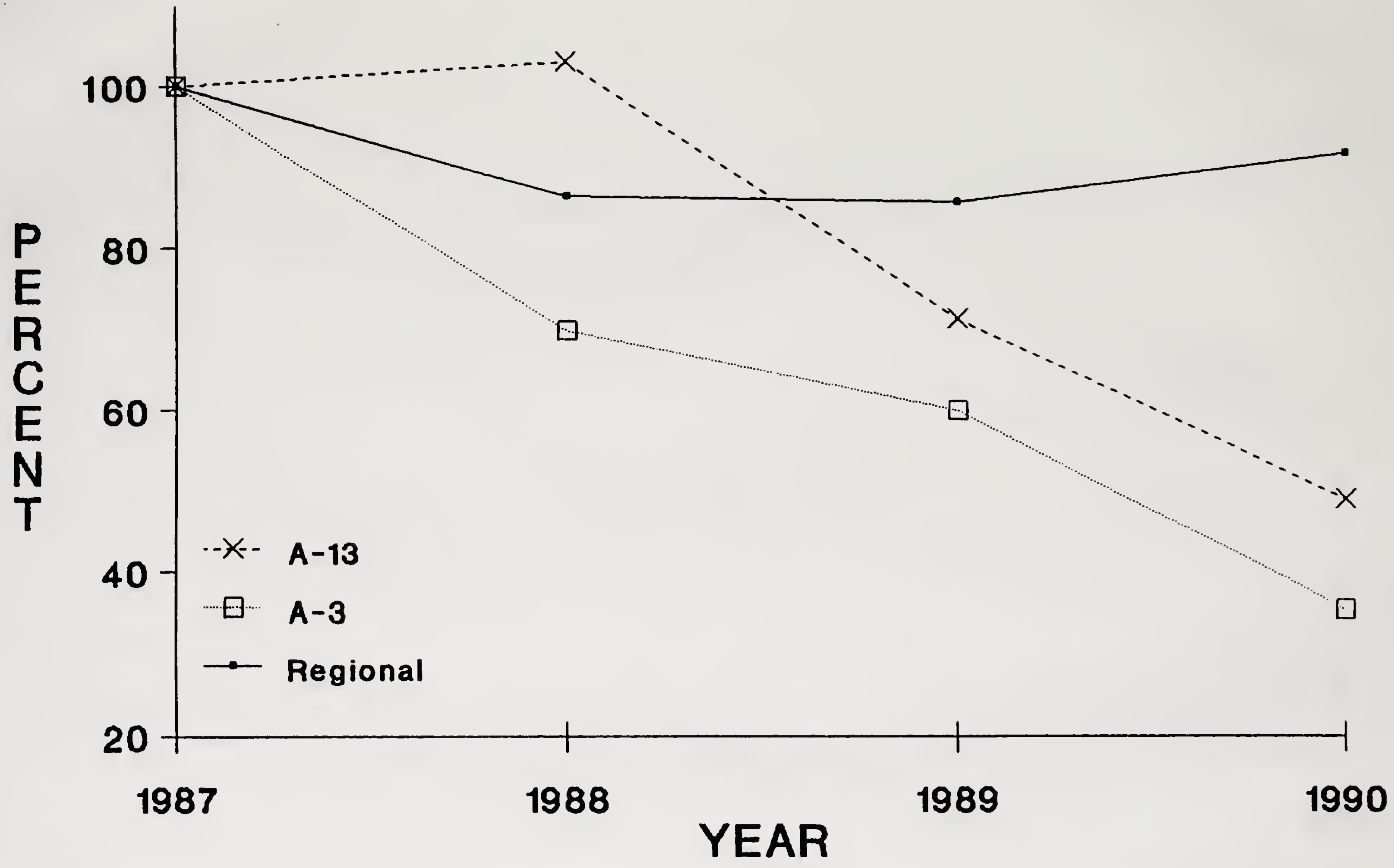

Figure 1. Regional and study area spring population densities compared to pre-study (1987) levels, Crab Orchard NWR, Illinois, 1987-1990.

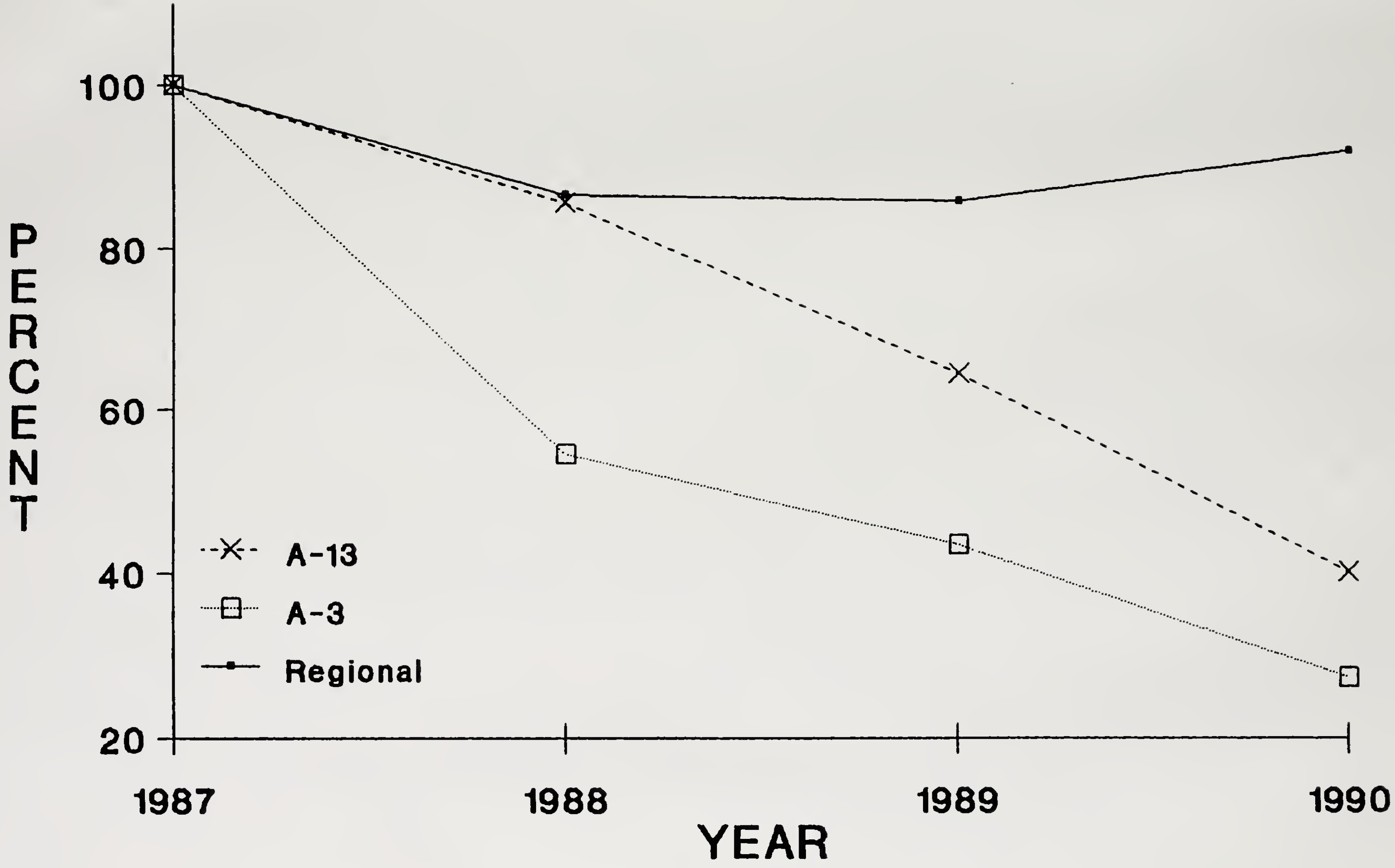

Figure 2. Regional and study area fall population densities compared to pre-study (1987) levels, Crab Orchard NWR, Illinois, 1987-1990.

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